PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
	Ozluturk et al.
Application No.:	10/726,372
Confirmation No.:	**7154**
Filed:	December 3, 2003
For: USER COGNITIVE ELECTRONIC DEVICE	
Group:	2617
Examiner:	Anthony S. Addy

Our File: I-2-0566.1US

Date: **October 15, 2007**

DECLARATION UNDER 37 C.F.R. § 1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Prabhakar Chitrapu, make the following declaration:

1. I am a named inventor of the above-identified patent application and co-inventor of the subject matter described and claimed therein.

2. On May 29, 2003, which is prior to June 20, 2003, my co-inventors and I completed an invention entitled USER COGNITIVE ELECTRONIC DEVICE (hereinafter "the present invention") as described and claimed in the above-identified patent application.

3. On or before May 29, 2003, we prepared Inventor's Notes describing the present invention. True and correct copies of the Inventor's Notes are attached hereto as Exhibit A.

4. The above-identified Application claims priority from U.S. Provisional Application Serial No. 60/506,079, filed September 24, 2003. Due diligence was exercised from May 29, 2003 on which the Inventor's Notes were prepared up to the filing date of Provisional Application No. 60/506,079 and the subsequent filing of the present application based thereon.

The undersigned hereby declares that all statement made herein are based upon his own knowledge and are true and that the statements were made with the knowledge that willful false statements will be punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize of the validity of the application or any patent issued thereon.

Prabhakar Chitrapu 10/15/07

Prabhakar Chitrapu Date

Cognitive Radio

State of Our Understanding

For

Skull Time Application

Cognitive Radio:
Making Software Radios More Personal

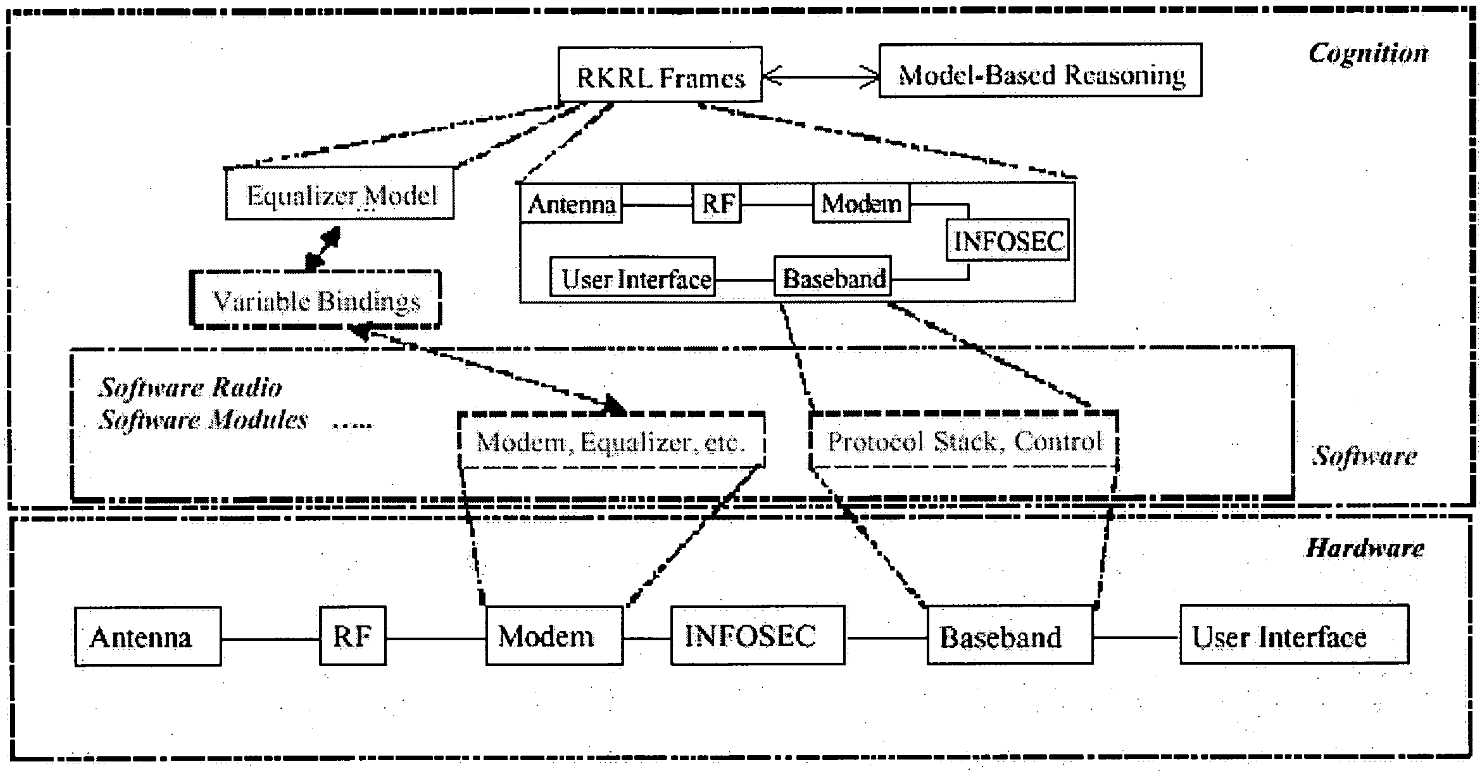


Figure 4-1 Cognitive Radio Framework

CR models 'itself', reasons based on model values, controls/modifies itself based on reasoning results, communicates such 'self-knowledge' to Network.

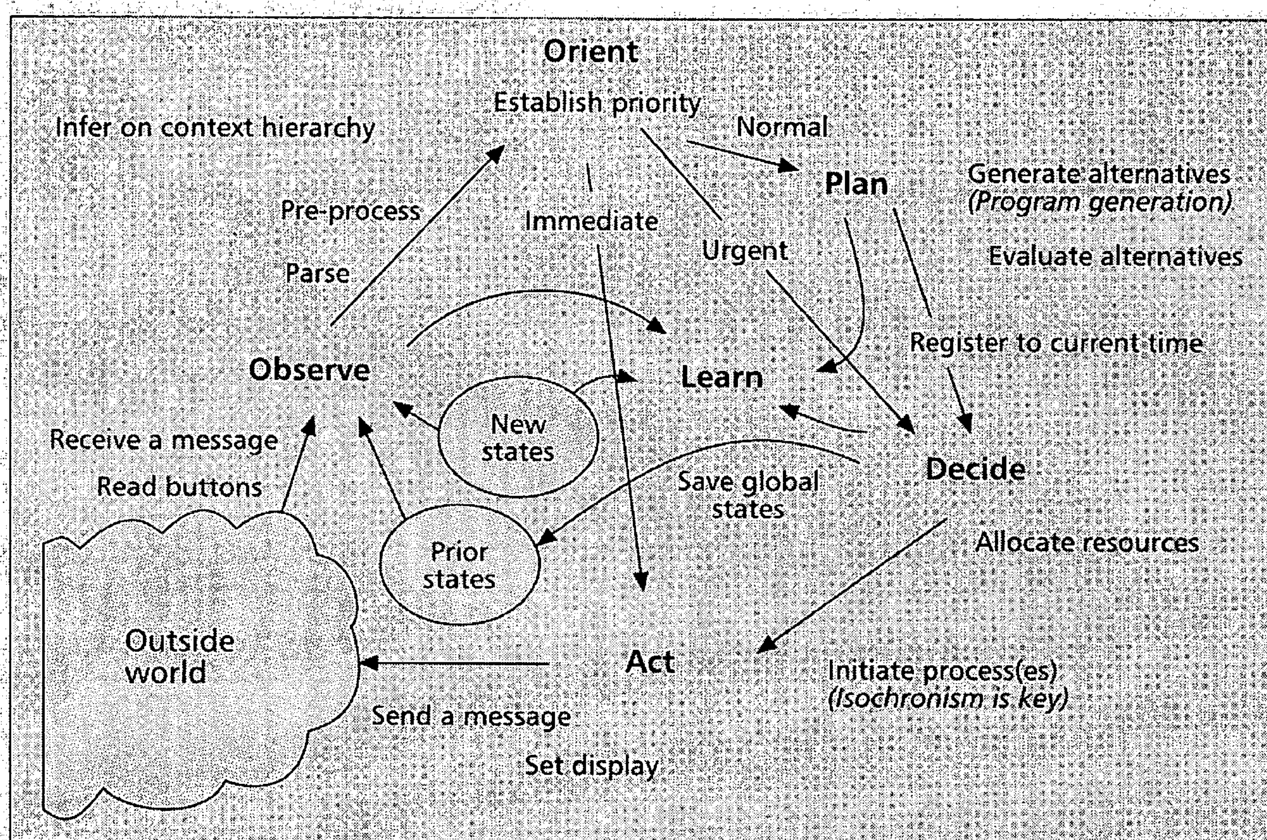


Figure 6. *The cognition cycle.*

The Cognition Cycle

RKRL supports the cognition cycle illustrated in Fig. 6. The outside world provides stimuli. Cognitive radio parses these stimuli to extract the available contextual cues necessary for the performance of its assigned tasks. It might analyze GPS coordinates plus light and temperature to determine whether it is inside or outside a building. This type of processing occurs in the observe stage of the cognition cycle. Incoming and outgoing messages are parsed for content, including the content supplied to/by the user. This yields contextual cues necessary to infer the urgency of the communications and related internal tasks. This task is akin to topic spotting in natural language processing. Even relatively high word error rates can result in high probability of detection and low false alarm rate in detecting ordinary events. Thus, the radio "knows" it is going for a taxi ride (with some probability) if the user packets at the wireless information kiosk order a taxi. If the main battery has just been removed, however, the orient stage *immediately* acts to save data necessary for a graceful startup and to shut the system down. Loss of carrier on all available links (e.g., due to entering a building) can result in *urgent* steps to restore connectivity, such as scanning for an in-building PCS or RF LAN. Most other *normal* events might not require such time-sensitive responses, resulting in the plan-decide-act cycle. The act step consists of allocating computational and radio resources to subordinate (conventional radio) software and initiating tasks for specified amounts of time. RKRL also includes some forms of supervised and unsupervised learning.

Space-Time Scales of various types of Cognition

	Plane	Objects	Space	Time	Information sources
1	Global	Regions	10,000 km	1 yr	Travel itinerary
2	Regional	Cities	1000 km	1 week	Weekly planner
3	Metropolitan	Districts	100 km	1 day	Commuting pattern
4	Local	Buildings	1 km	1 hr	GPS, lunch?
5	Immediate	Rooms	100 m	1 s–1 min	Dead reckoning
6	Fine scale	Body parts	1 m	1 µs	Equalizer taps
7	Internal (radio)	HW, SW	.1 m	1 ns	Architecture

■ **Table 4.** *The phusical world inference hierarchy; HW, SW: hard/software.*

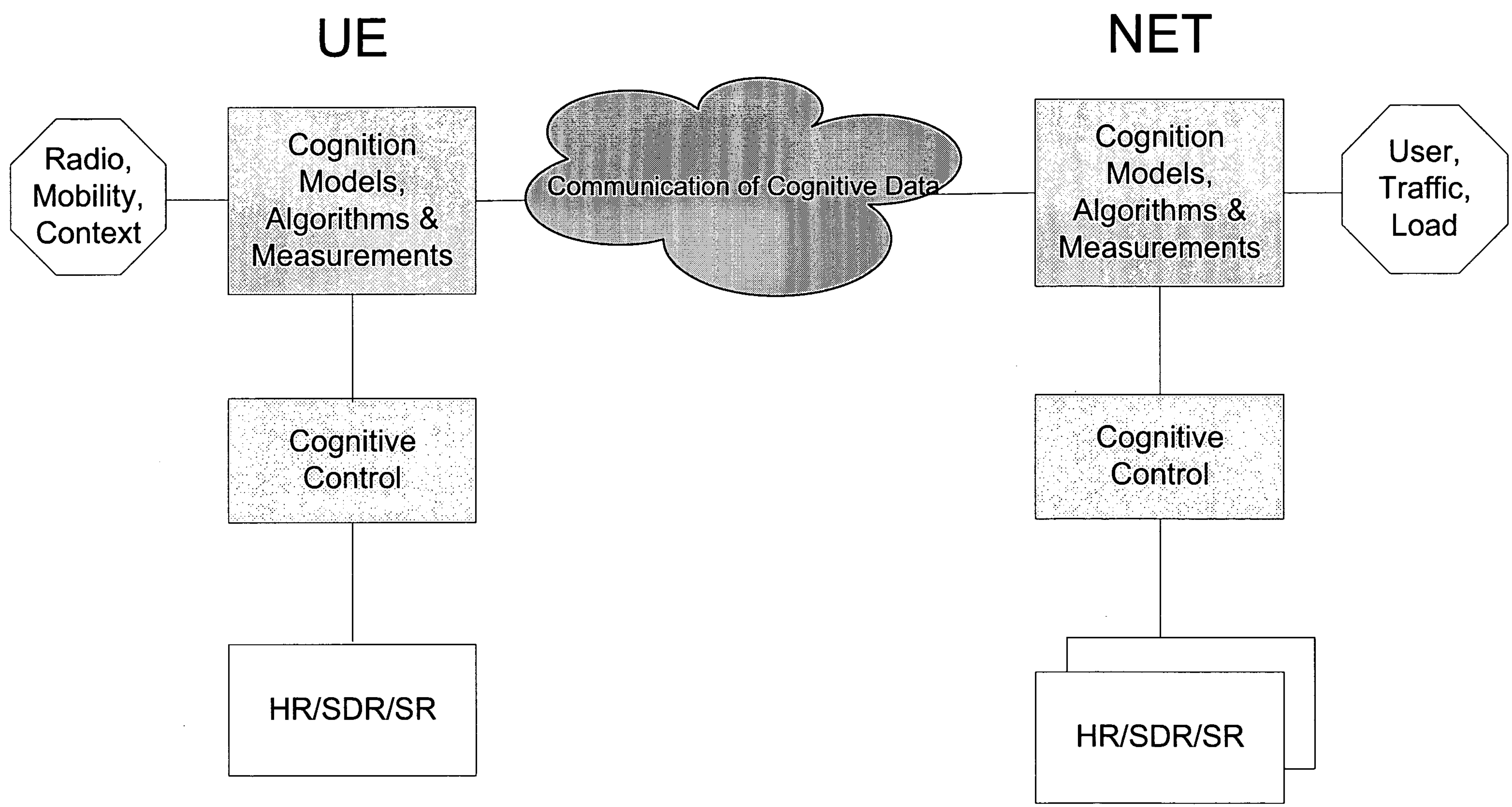
IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 17, NO. 5, MAY 1999

Adaptive Radio for Multimedia Wireless Links

Charles Chien, *Member, IEEE*, Mani B. Srivastava, Rajeev Jain, *Fellow, IEEE*,

Paul Lettieri, Vipin Aggarwal, and Robert Sternowski, *Member, IEEE*

An adaptive radio is designed that
adapts the frame length, error control, processing gain, and equalization
to different channel conditions, while
minimizing battery energy consumption.



UE
NET
Radio, Mobility, Context
Cognition Models, Algorithms & Measurements
Communication of Cognitive Data
Cognition Models, Algorithms & Measurements
User, Traffic, Load
Cognitive Control
Cognitive Control
HR/SDR/SR
HR/SDR/SR

Table-1: Physical Modeler Attributes

Radio Related Attributes	• Multipath attributes • Shadowing attributes • Doppler attributes
Geo-location related attributes	• Buildings • Trees • Atmospheric attributes

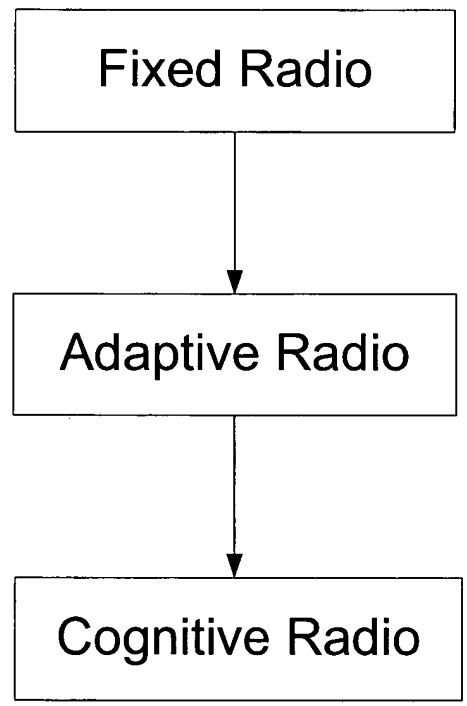
Table-2: Mobility Modeler Attributes

- Geo-cordinates
- Velocity
- Road Topology, including traffic lights etc.
- Traffic density

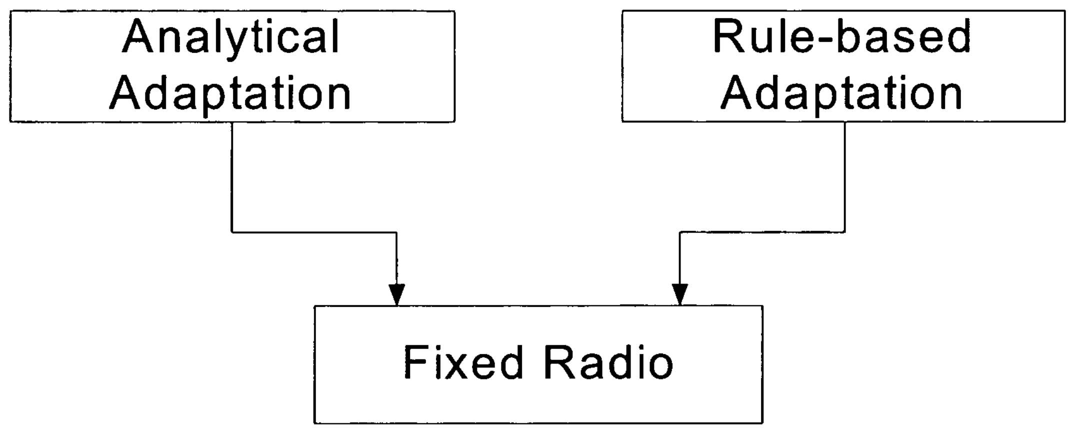
Table-3: Application Context Models

Application Micro-data-flow model	• Speech activity statistics • (IP) Packet Data statistics
Application Macro-data-flow model	• Email download followed by Attachment download followed by Document viewing process • HTTP Web page object distribution statistics
Application Control-syntax model	• 3-way TCP handshake process • HTTP signaling messages • Mobility management protocols, such as Location Updates, Context transfers etc • Essentially, any sequence flow process
Multi-Application Dynamics model	• Email & Instant Messaging

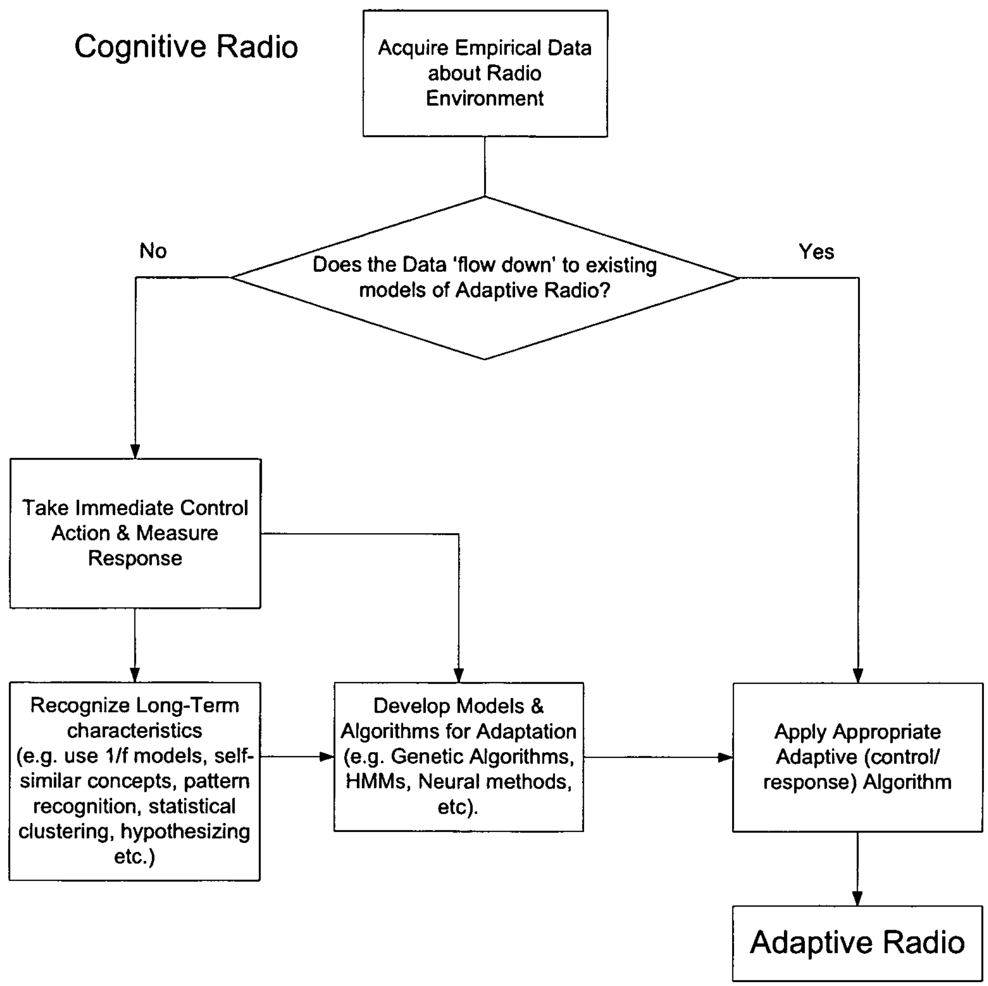
CR Architecture and Implementation



Adaptive Radio



Defining Characteristic of Adaptive Radio:
Essentially, any adaptive technique starts with a Model and an Adaptation Algorithm. For example, in an LMS FIR filter, the FIR filter is the model of the channel and LMS is the Adaptation Algorithm. Similarly for a Rule-based Adaptation scheme, although in this case, the Model may be implicit and may not be explicitly recognizable. However, in all cases, the basic presumption of an Adaptive Radio is that the Radio-related Models and associated Adaptation Algorithms are PRE-DETERMINED AND FIXED.



Defining Characteristics of Cognitive Radio:
To put it simply, the need for Cognitive Radio occurs when Adaptive Schemes cannot work. Since Adaptive Radios are characterized by the presumption of pre-determined Radio Models and Adaptation Algorithms, it follows that Cognitive Radio comes into picture when either Radio Models or Adaptive Algorithms are not available. That is, when the Radio environment exhibits behavior or data that is beyond the scope of the existing Adaptive Radio capabilities, the Cognitive Radio is called for. Therefore, the starting point of a Cognitive Radio is new types of empirical data from the Radio Environment. The Cognitive Radio attempts to recognize data that is beyond the scope of the Adaptive Radio, to deal with the new data in an intelligent way in the short term, to develop long term learning from this new data (i.e. develop 'models') and finally to develop long term response algorithms (generalizations of adaptive algorithms). These steps are depicted in the picture.

Prabhakar Chitrapu, April 4, 2003.
InterDigital Proprietary & Confidential

Project description: Develop a cognitive wireless system that can intelligently self-configure based on environment

Characterize the wireless environment
- Considering spectral utilization, geography, membership, interference, propagation, legal (FCC)
- Accomplish utilizing GIS, GPS, channel sounder, channel models, user profile

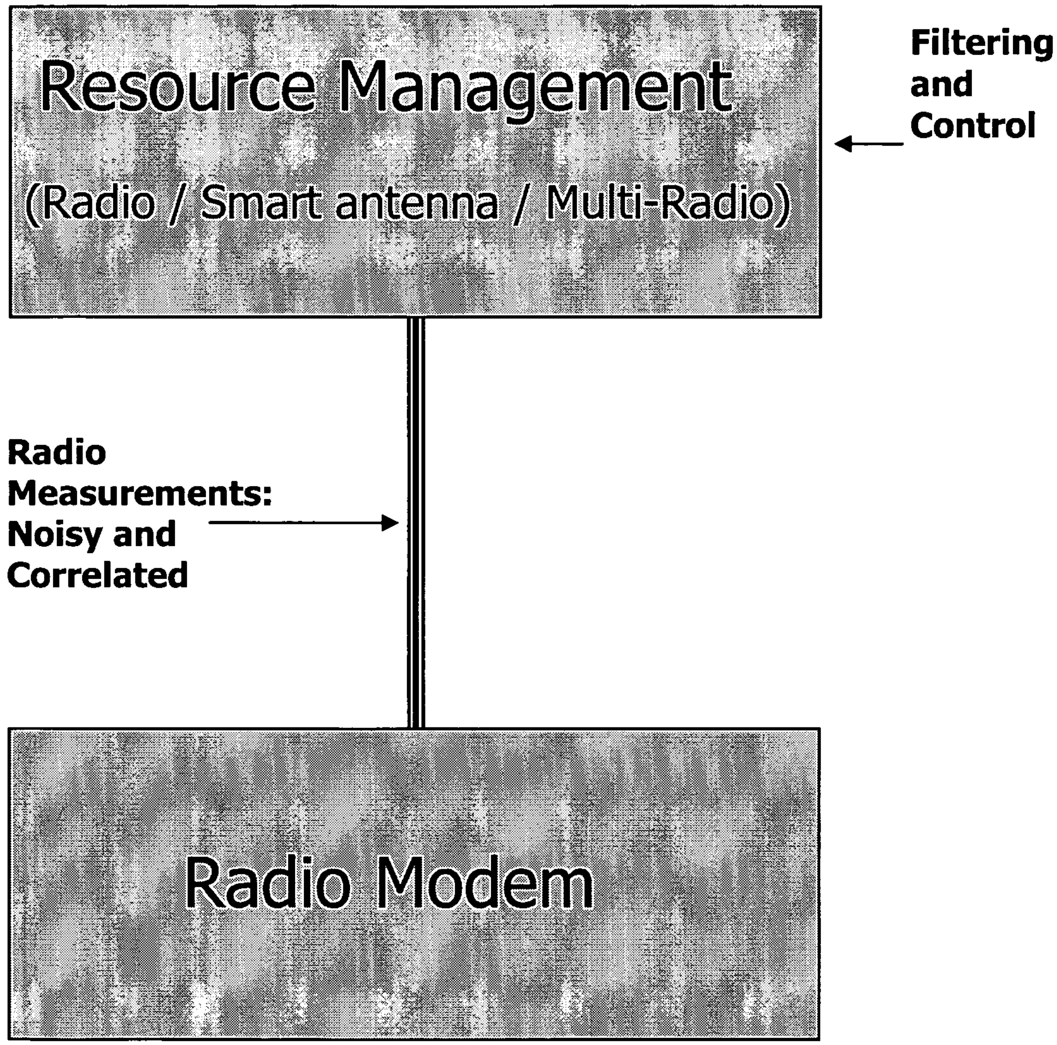
Optimize the performance of the adaptive wireless system subject to constraints
- Performance metrics: throughput, delay, QoS, coverage
- Constraints: battery, interference to others
- Establish framework of time varying requirements

Given the environment and optimal requirements, reconfigure radio parameters
- Parameters include coding, ARQ, Tx Power, beam forming, modulation, space codes, air interface, processing gain, frame length, data rate

- Create Cognitive Radio Models (HMM, NN, Wavelet, GA) that monitor and map system requirements and specific environment to optimally set radio parameters

- Cognitive Radio Models will become hardware and software that define a new intelligent layer for resource management

Traditional Radio Network



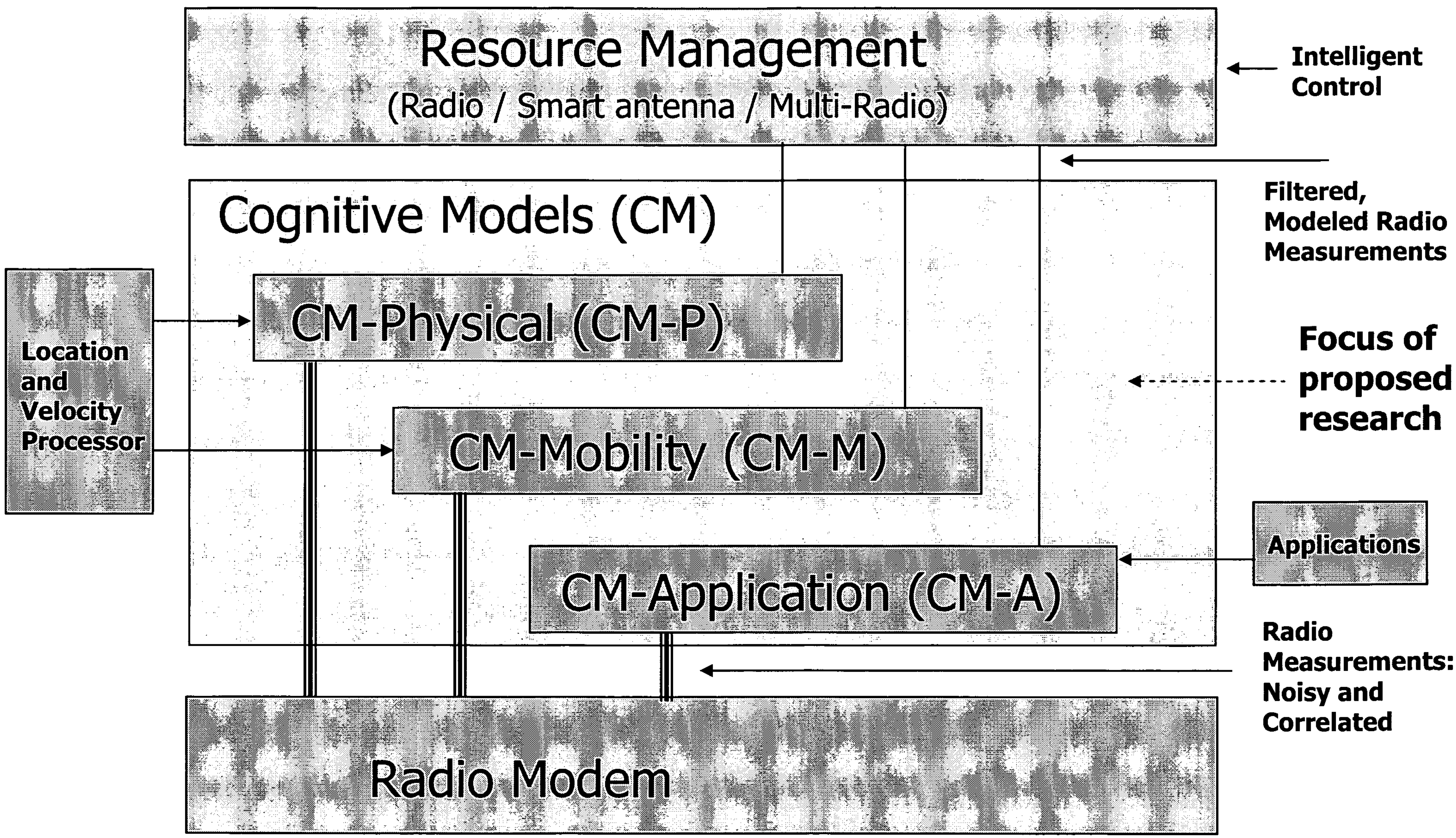
Problems arise as the number and type of radio measurements increase

•Optimization Layer becomes more and more complex and **uncoordinated**

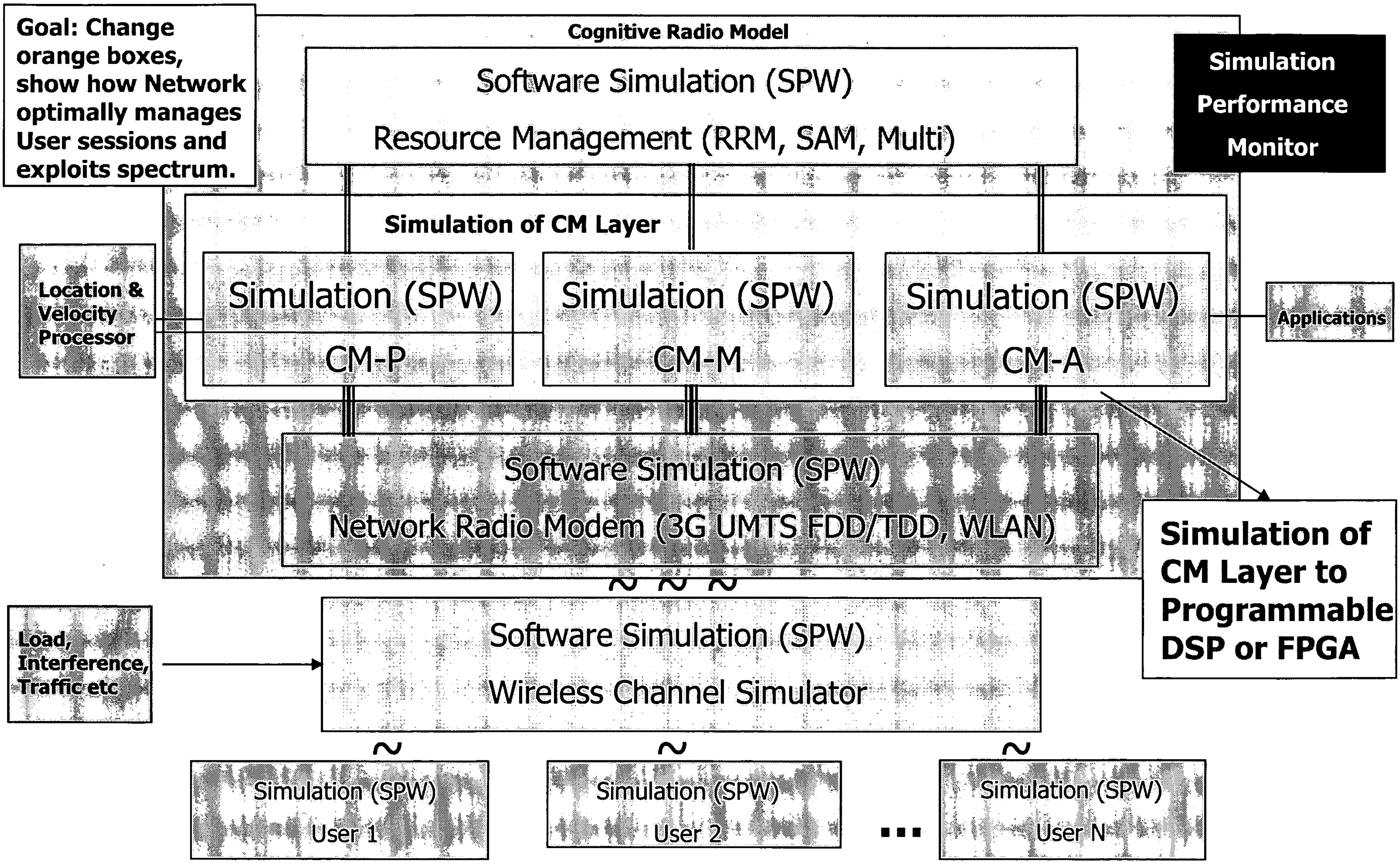
•Adaptive controls will develop in an ad-hoc unstructured manner

•Difficult to manage

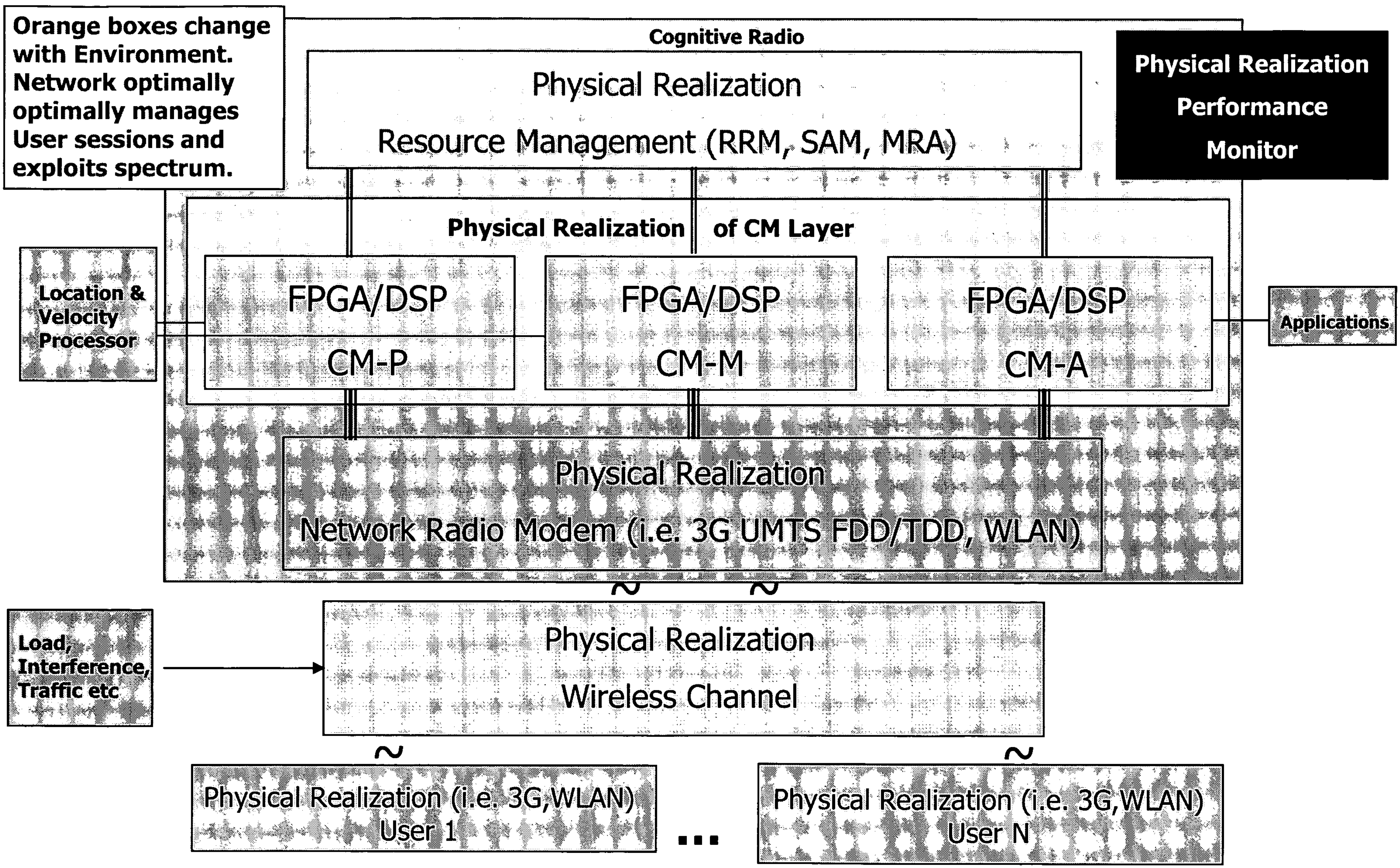
Cognitive Radio (CR) Network



Simulation of Cognitive Radio Model (CRM)

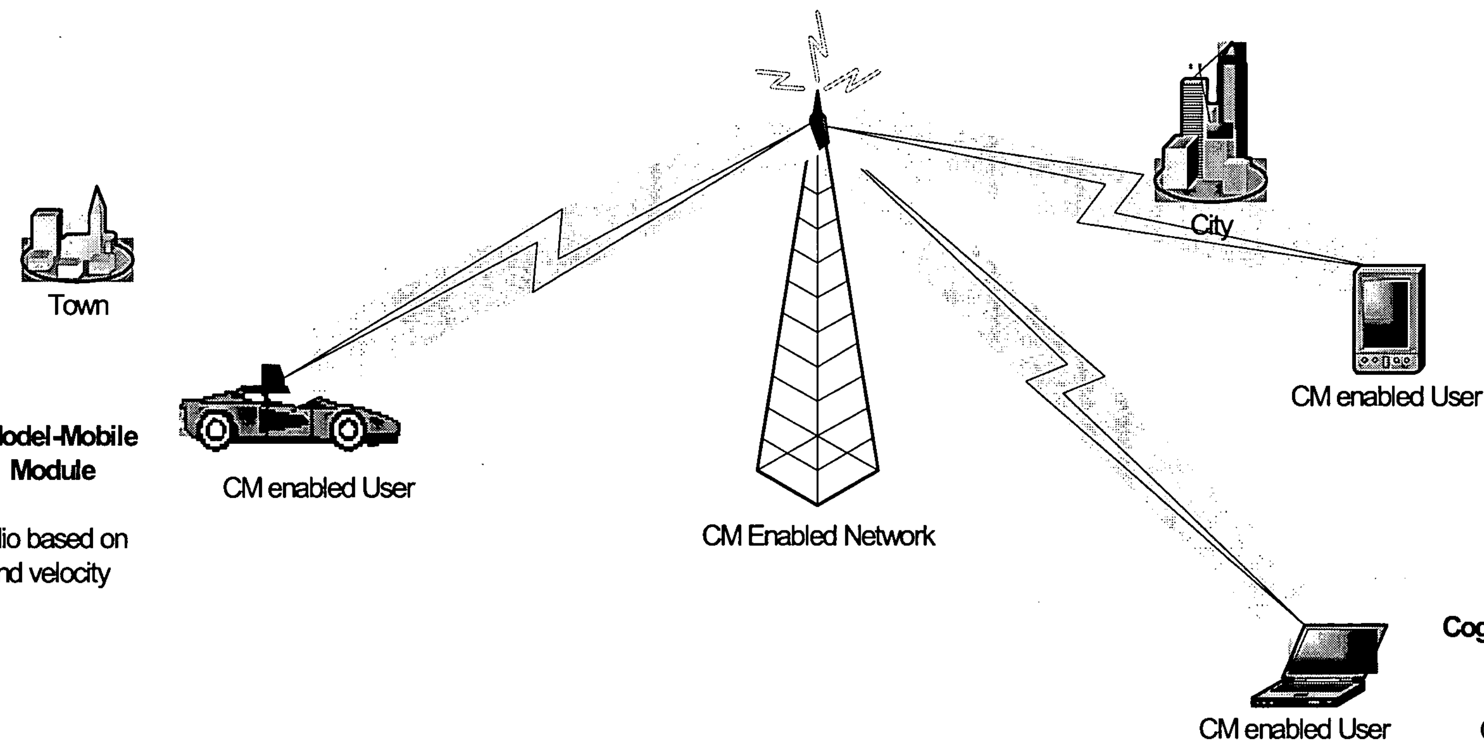


Physical Realization of CRM



Cognitive Radio System

- Sample Cognitive Radio Network



Cognitive Model-Mobile (CM-M) Module

Change radio based on location and velocity

Cognitive Model- Physical (CM-P) Module

Change radio based on local radio environment

Cognitive Model-Application (CM-A) Module

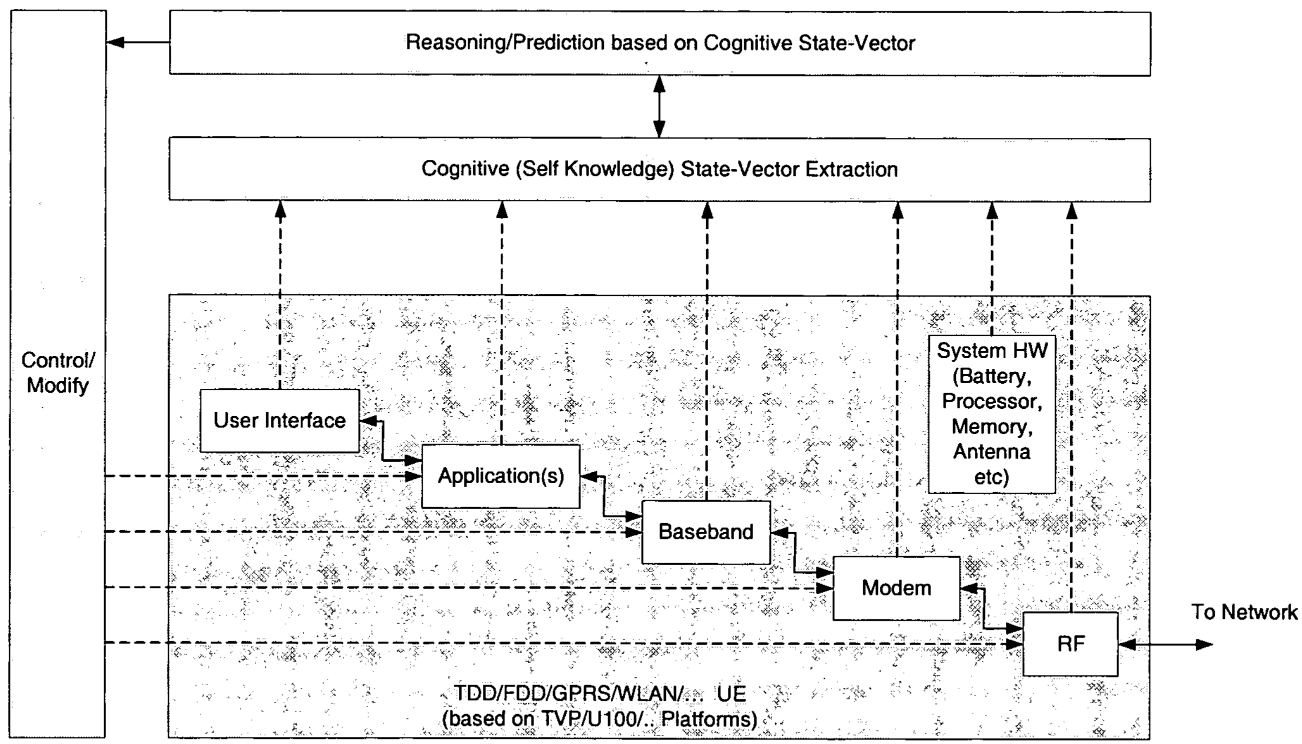
Change radio based on requirements of application

Cognitive Radio

Ideas/Proposals

Product Idea-1: Yellow = New Development

Cognitive MiddleWare (Comware) for Adaptive UEs



Cognitive Middleware for Adaptive UE

- Start with an existing Radio Platform, such as TVP or U100.
- Identify all possible parameters in the Radio Platform which give information about the Radio Environment, Platform Load, Application Context and User Commands.
  - Radio Environment parameters:
    - Signal Levels, Noise levels, Interference levels, BER, BLER, Estimated Channel parameters including Delay Spread, etc.
  - Platform Load parameters:
    - Battery level, CPU loading, Memory utilization, Antenna position etc.
  - Application Context parameters:
    - Protocol State such as HTTP or TCP etc.
  - User Command parameters:
    - Obtain map information, restaurant information, etc. (see Mitola's paper for how such information may be used in a Cognitive Radio)
- These parameters define the Cognition-State-Vector (or Self-Knowledge-State-Vector).
- Make necessary changes to the platform, to expose these parameters.
  - Opportunity for developing standardized APIs
- Extract and, if necessary, filter the Cognition-State-Vector sequence.

Cognitive Middleware for Adaptive UE

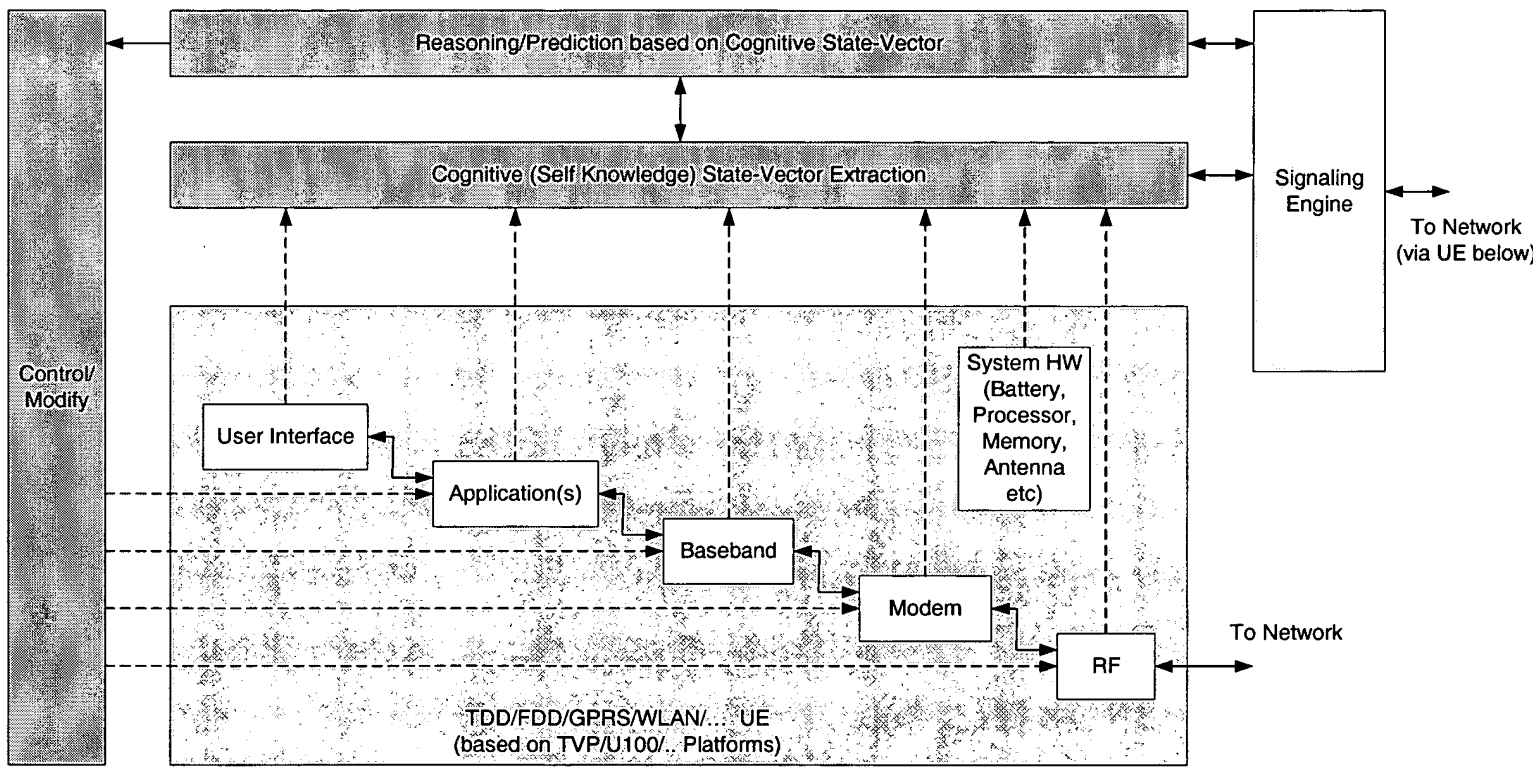
- Develop prediction models for predicting the future values of some or all of the Cognition-State-Vector and perform the prediction
  - Begin with simple rule based schemes
  - Later, incorporate more complex models such as Models based on HMMs trained by Genetic Algorithms (developed by VT)
- Develop <u>Adaptive Radio</u>
  - Quantities to be optimized.
    - Radio Link performance quantities such as BER, Latency, Throughput, Goodput, Transmitted Power,
    - Platform parameters such as Battery Power Consumption, CPU utilization, Memory utilization, etc.
  - Parameters to be adapted/controlled
    - Data Block/Frame lengths, FEC schemes, Coding Rates, Modulation schemes, etc.
  - Adaptation/Control schemes/algorithms

Summary

- Proposal for developing a Middleware Framework for Adaptively Optimizing UE performance.
- We begin with simple quantities to be optimized, simple observations and simple control rules.
- Future Proof: As more sophisticated cognitive solutions are developed, they can be 'dropped' into the already developed framework.
- Reuse: The Middleware Framework can be ported to other platforms, thereby enabling new marketing/sales channels for the product.
- <u>Enriched BREW</u> solution:
  - We could even develop the Comware based on Qualcomm's BREW.
  - BREW today exposes the Radio only for the purposes of Application Development, but not for Radio Control/Optimization. Enrichment does exactly that.

IPR/Product Idea-2: Green = New Development

Protocols for Cognitive Systems (UE+Network)



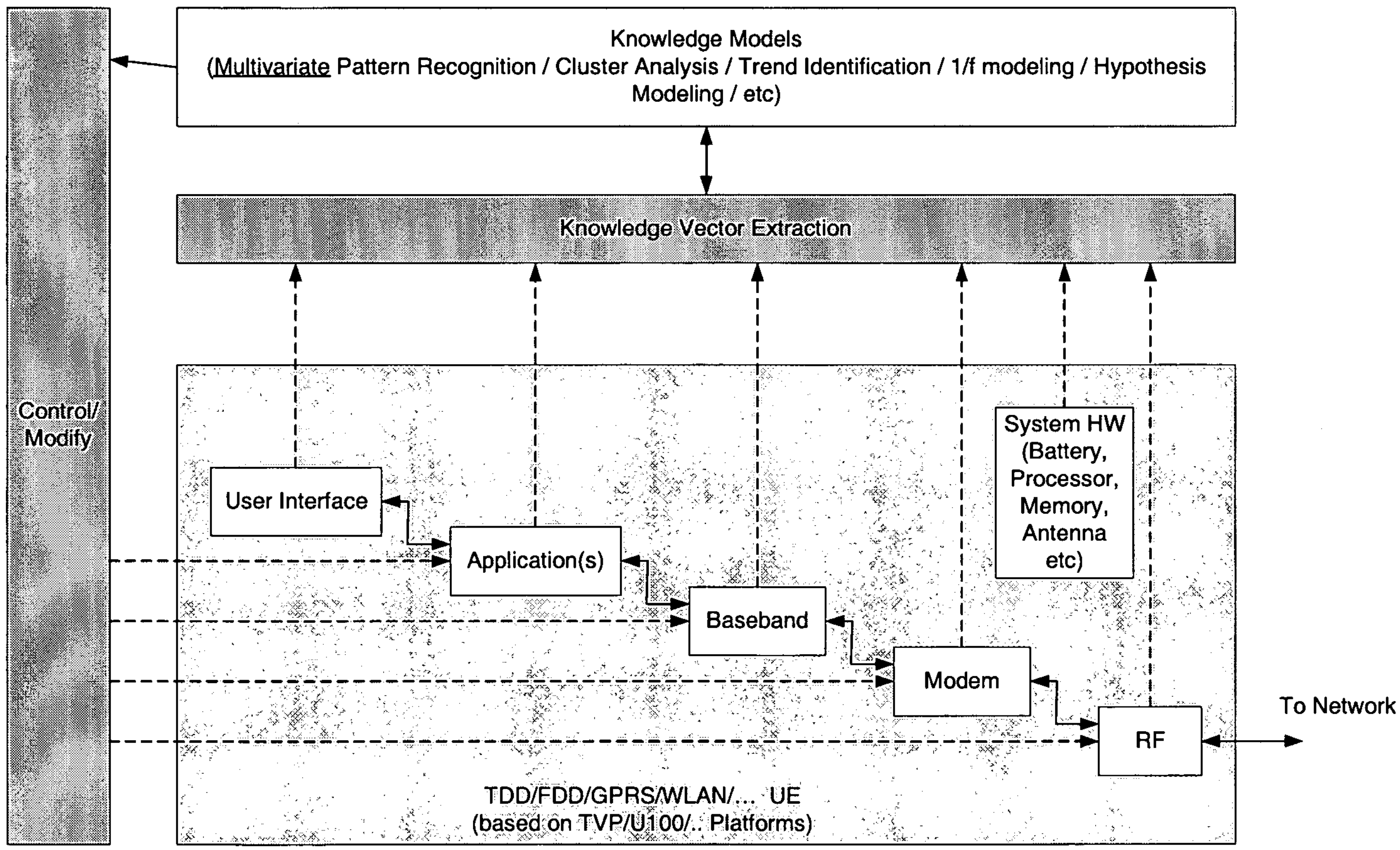
Yellow Box: Develop messaging structures and protocols for communicating and controlling.
Green Box: Already Covered as per previous Idea.

Summary

- Develop messaging structures and protocols for communicating and controlling

IPR Idea-3: Green = New Development

Knowledge Models for Cognitive Radio



Knowledge Models

- Types of Knowledge Vectors
  - Related to User Data Communications Process
    - RF parameter vector (sequenced in time)
    - Modem parameter vector
    - Baseband Processor parameter vector
    - Application context vector
    - User Interface parameter vector
  - Related to Received Information
    - Vector containing information received by Peer entity
  - Related to System operation (UE or BS)
    - Vector containing Battery power consumption, Processor and Memory Utilization etc.

Additions in Red font

Knowledge Models

- Knowledge Vectors contain information about common phenomena in
  - Correlated form: That is, multiple knowledge vector types have information about the same thing.
  - Multi-Scale Form: That is, different knowledge vector types have information about the same phenomenon at different scales (of granularity in time, values etc).
  - Alain's Example: A is driving to work, sees his average speed is decreasing (knowledge vector type 1); sees increasing number of cars (knowledge vector type 2); sees some police cars going by (knowledge vector type 3). All these 3 types of knowledge vectors have information about the 'phenomenon' that an accident may have occurred down the road. Arriving at that conclusion/hypothesis is an example of building Knowledge Model.
  - Alan Greenspan Example: How does Alan Greenspan decide to increase or decrease the Fed interest rates? He uses information (knowledge vectors) of many different types: economic data; joblessness data; national debt data; war/hostilities impacts; political information etc etc. He will 'fuse'/'synthesize' all these knowledge vectors into a common model and a common objective of interest rate control.
    - Hence a Project Code Name: Greenspan in a Box.
- Knowledge Models can be generated based on:
  - <u>Multivariate</u> Pattern Recognition / Cluster Analysis / Trend Identification / 1/f modeling / Hypothesis Modeling / etc

Product Idea - 4: Yellow = IDCC Product

Wideband RF for
SDR based Universal Handsets